



# Satellite-based thunderstorm tracking, monitoring and nowcasting over South Africa

Caroline Forster<sup>1</sup>, Estelle de Coning<sup>2</sup>,  
Sebastian Diebel<sup>1</sup>, Tobias Zinner<sup>3</sup>

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1 DLR Institute of Atmospheric Physics, Oberpfaffenhofen, Germany

2 South African Weather Service

3 Meteorological Institute, University of Munich, Germany

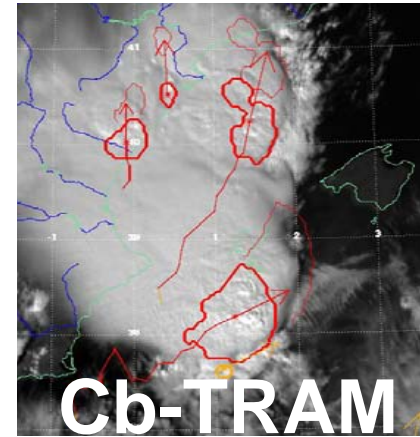


Deutsches Zentrum  
für Luft- und Raumfahrt e.V.  
in der Helmholtz-Gemeinschaft



# CB-TRAM - Cumulonimbus Tracking And Monitoring

(Zinner, Mannstein, Tafferner, MAP, 2008)

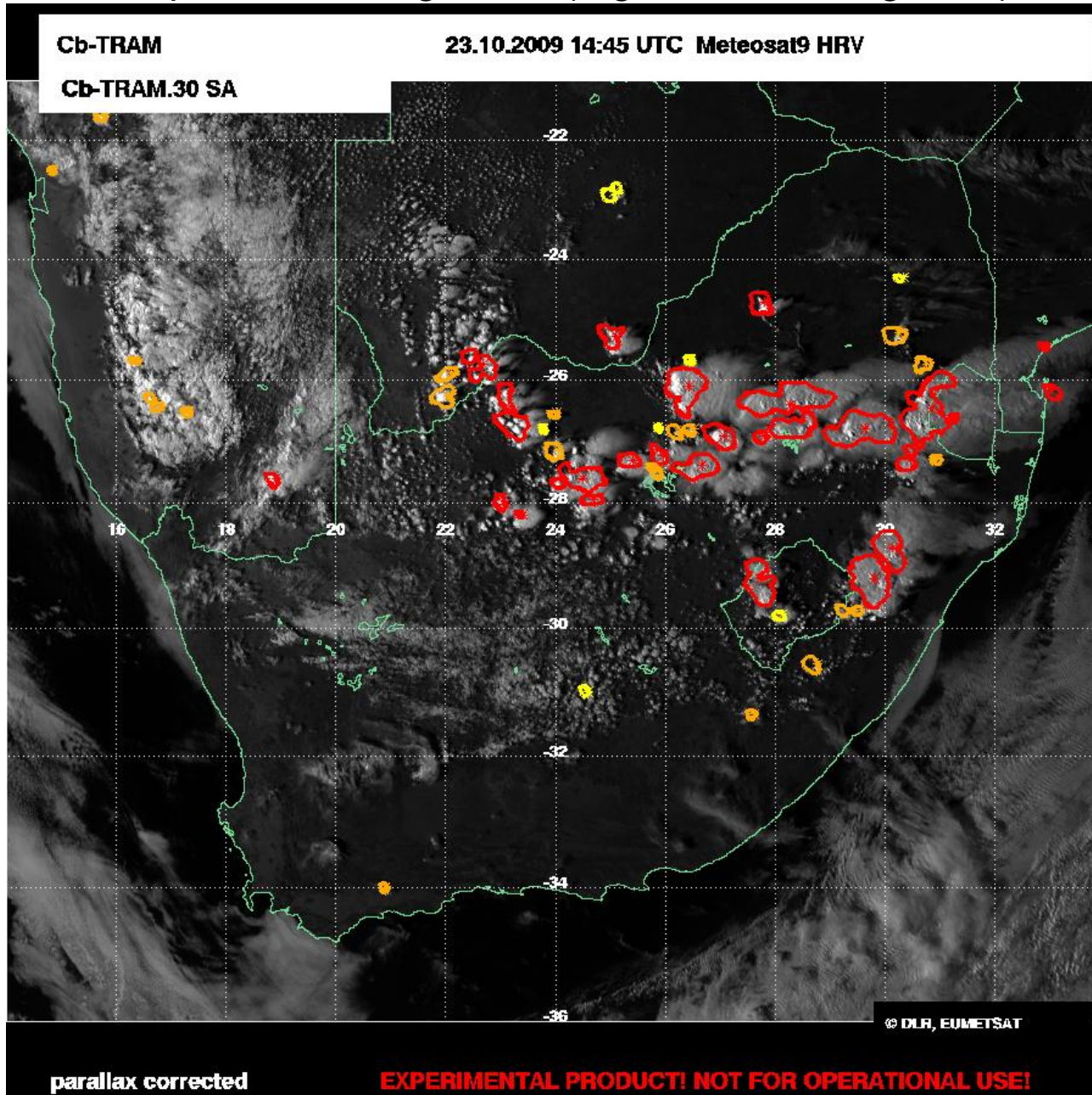


- Algorithm for the detection, monitoring and nowcasting of thunderstorms from space
- Use of Meteosat SEVIRI Data
  - ◆ Combination of HRV, IR10.8, IR12.0 and WV6.2 data for detecting Cb cells
  - ◆ HRV info to localize the most active convective cells (texture in HRV image)
  - ◆ Tracking based on pyramidal image matching algorithm
- Distinction of 3 development stages
  - ◆ (1) First development of clouds (convection initiation)
  - ◆ (2) Rapid development (strong cooling of cloud top)
  - ◆ (3) Mature thunderstorm (reaching or exceeding the tropopause)
- Time resolution 15 min (or even 5 minutes with Meteosat rapid scan data)
- Nowcasts with extrapolation of detected features up to one hour

# CB-TRAM applied over South Africa for the first time



- adaption of the algorithm (e.g. to the moving HRV)



**yellow:**  
convection initiation (CI)

**orange:**  
rapid development

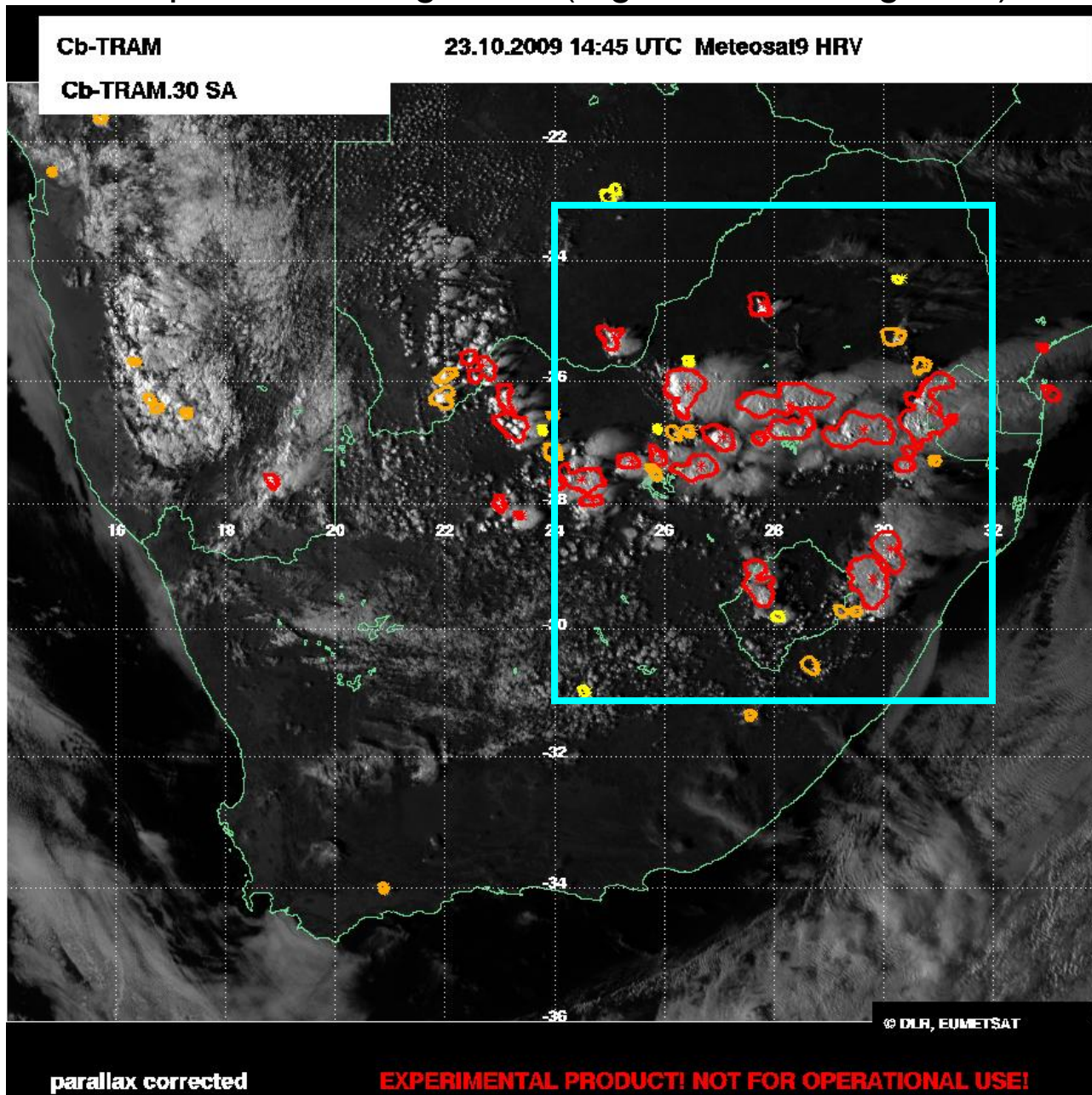
**red:**  
mature thunderstorm





# CB-TRAM applied over South Africa for the first time

➤ adaption of the algorithm (e.g. to the moving HRV)



**yellow:**  
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**red:**  
mature thunderstorm

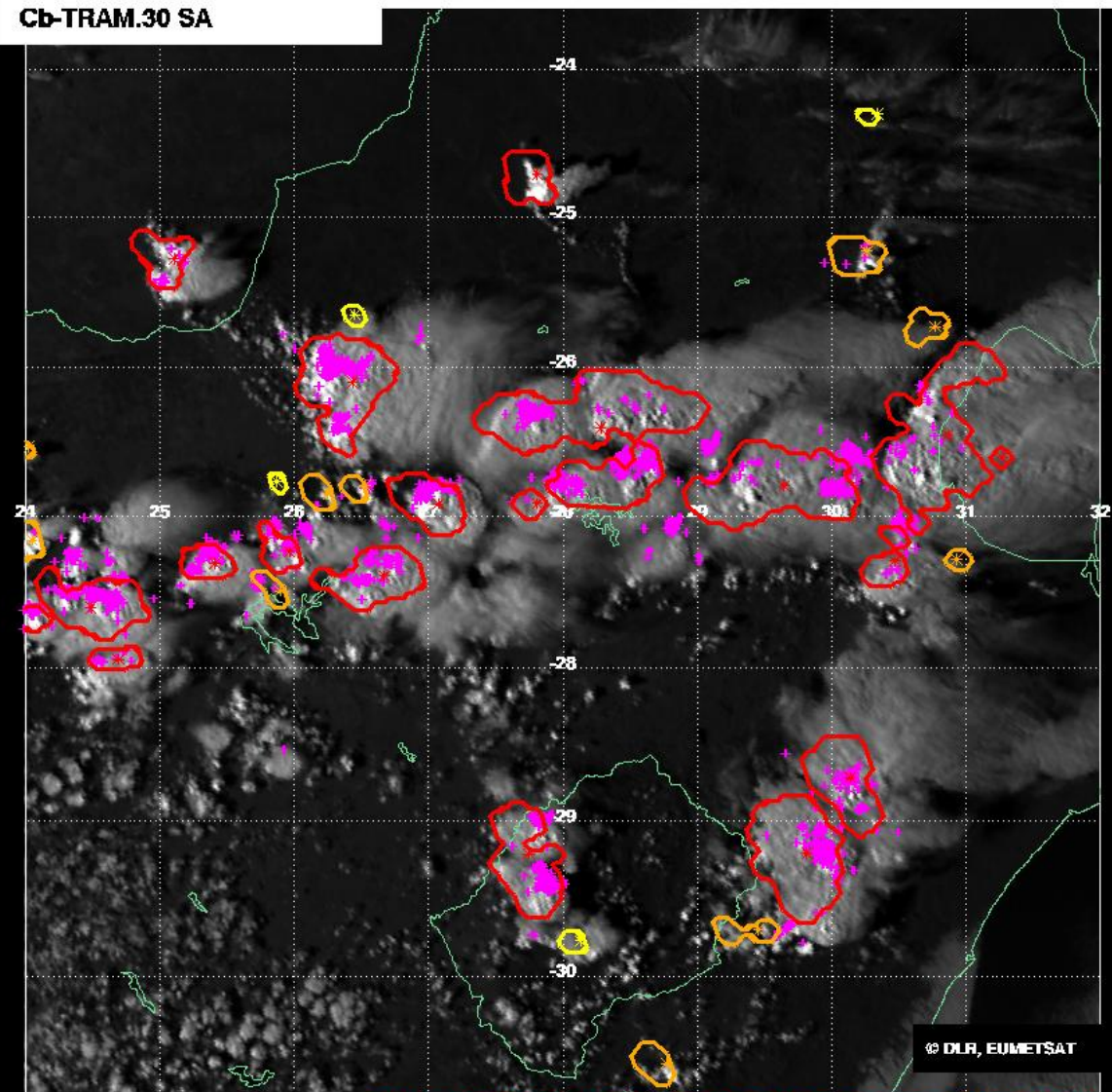
# CB-TRAM over South Africa



Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



**yellow:**  
convection initiation (CI)

**orange:**  
rapid development

**red:**  
mature thunderstorm

**pink:**  
lightning incidents

parallax corrected

**EXPERIMENTAL PRODUCT! NOT FOR OPERATIONAL USE!**

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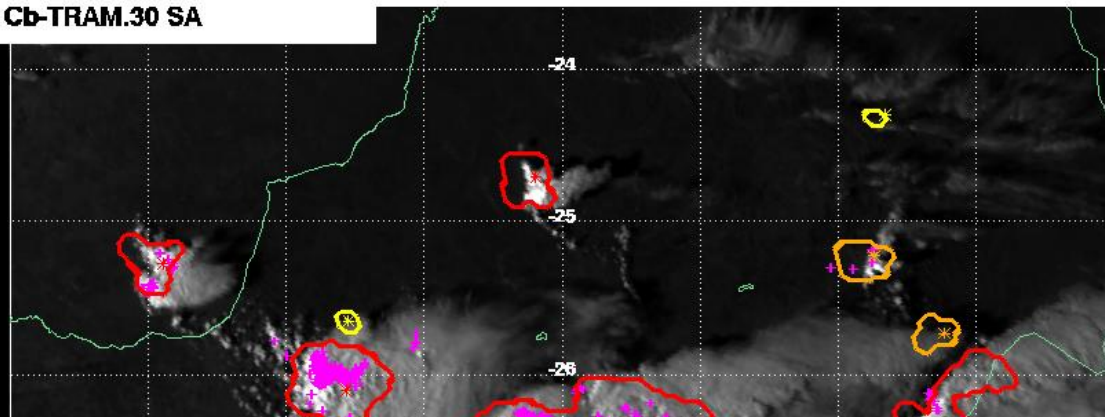
# CB-TRAM over South Africa



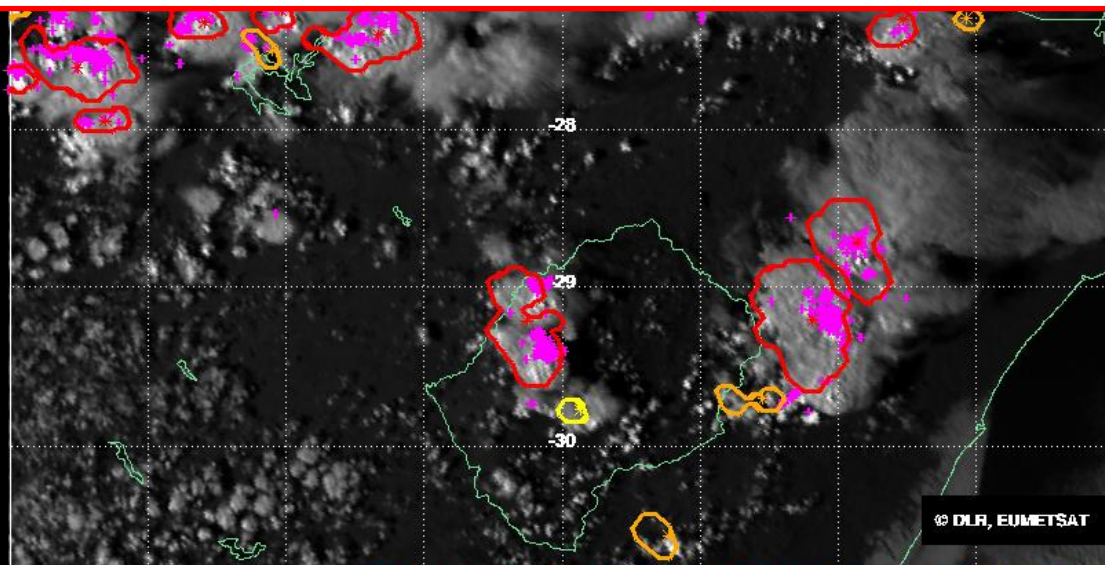
Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



CB-TRAM is able to detect the most turbulent areas within the anvil



parallax corrected

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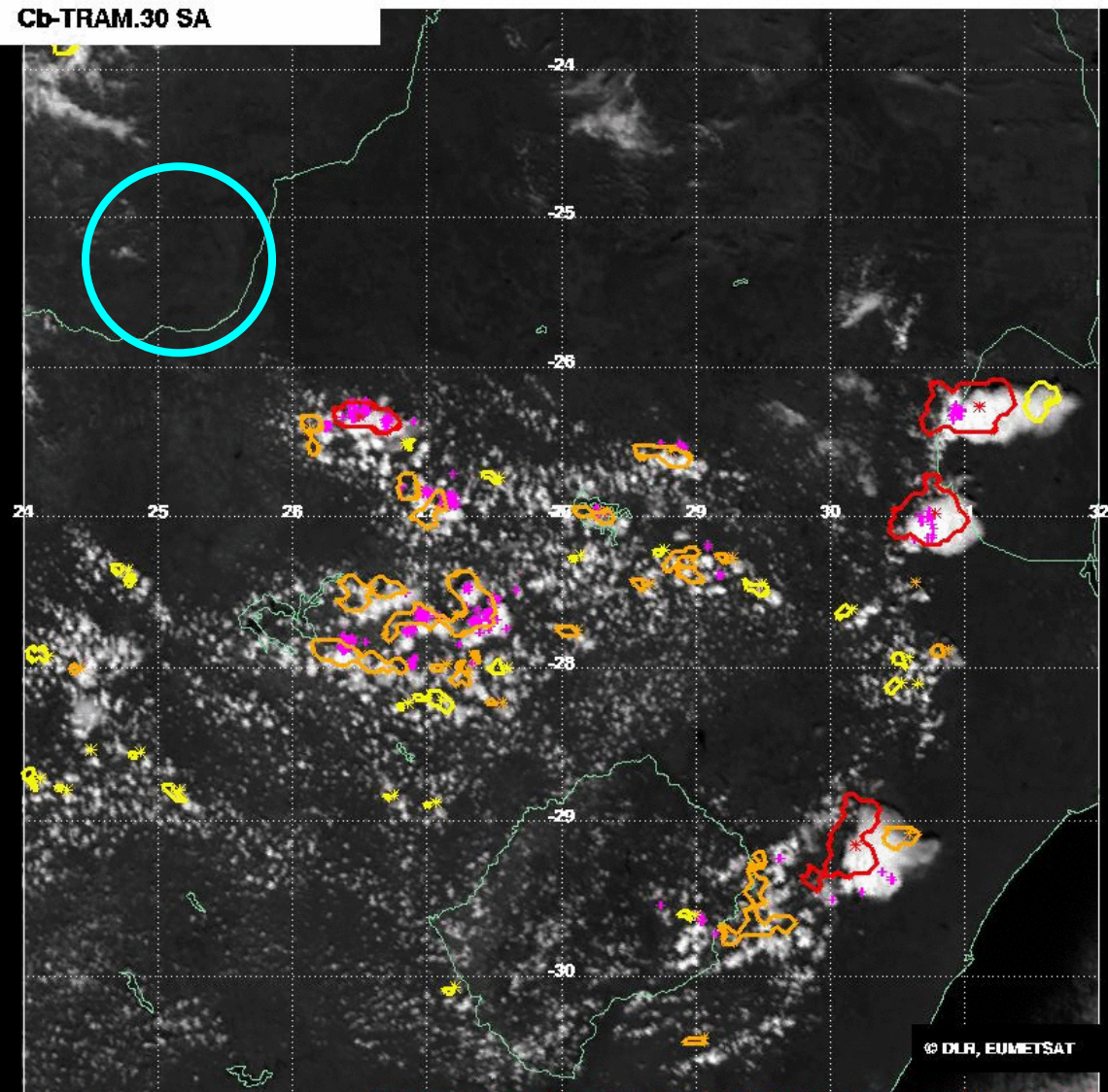
# CB-TRAM applied over South Africa



Cb-TRAM

23.10.2009 12:00 UTC Meteosat9 HRV

Cb-TRAM.30 SA



**yellow:**  
convection initiation

**orange:**  
rapid development

**red:**  
mature thunderstorm

**pink:**  
lightning incidents  
(0-10 min after image time)

parallax corrected

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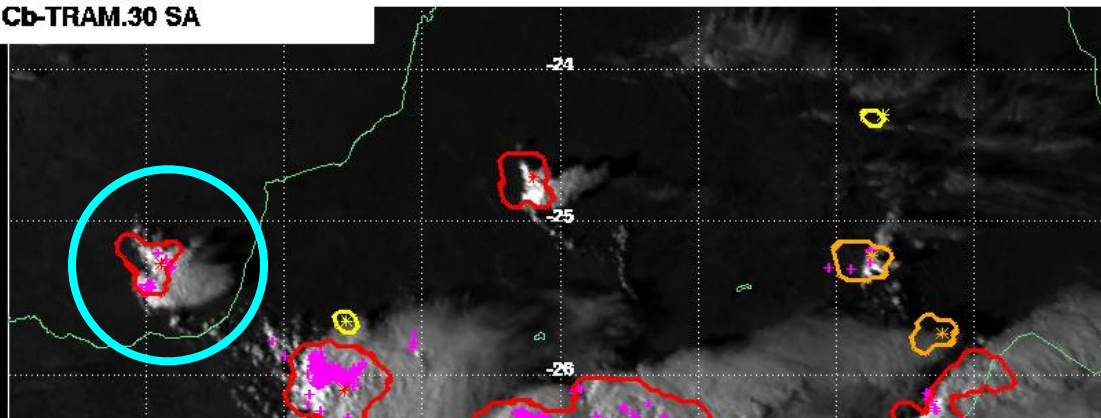
# CB-TRAM over South Africa



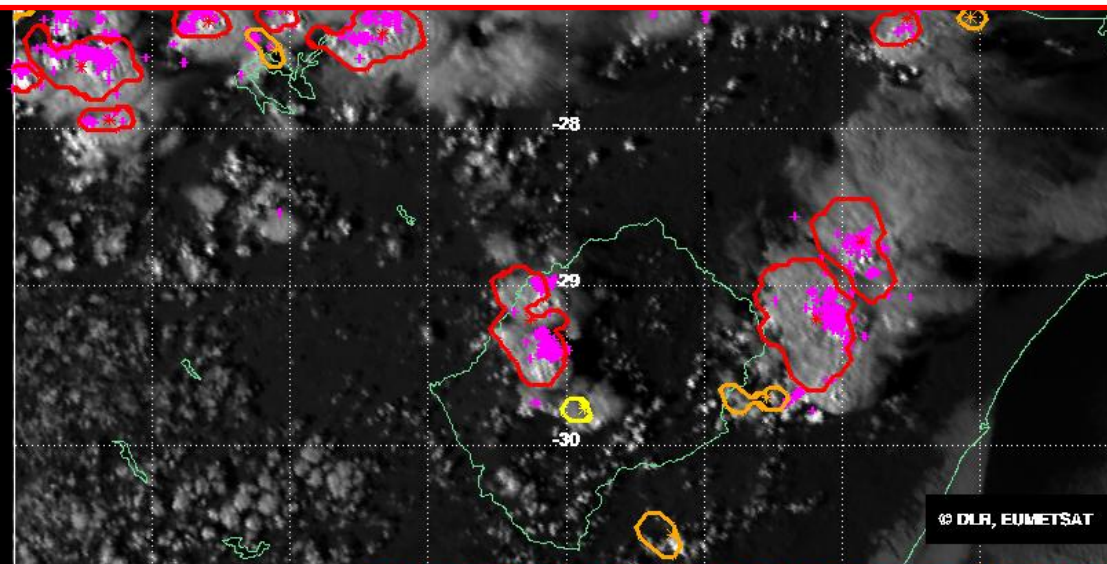
Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



Cb-TRAM is able to detect convection initiation before any lightning incidents occur



parallax corrected

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(0-10 min after image time)



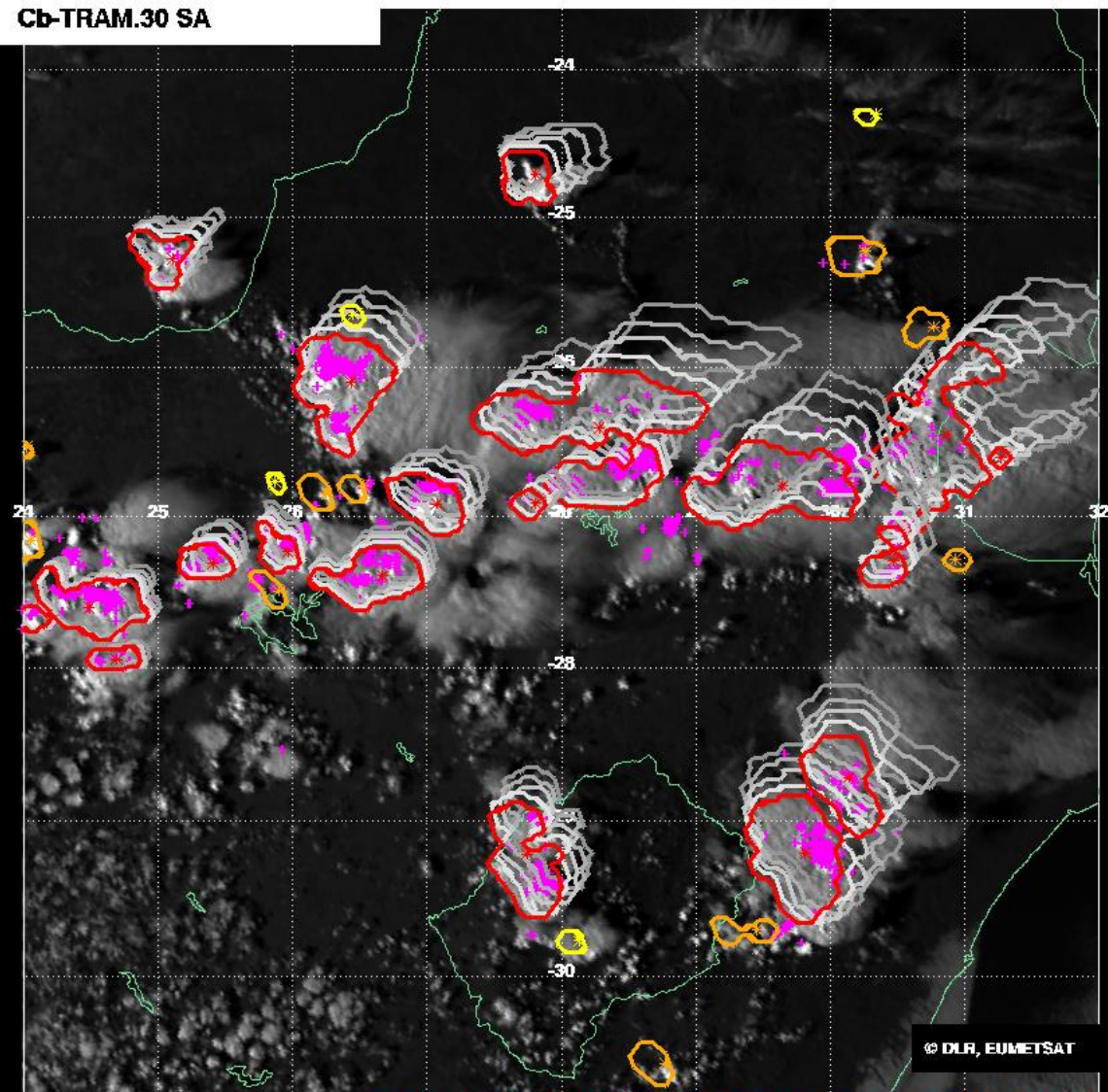
# CB-TRAM over South Africa



Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



**yellow:**  
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mature thunderstorm

**pink:**  
lightning incidents  
(0-10 min after image time)

**grey:**  
15, 30, 45, 60 Min.  
nowcast

parallax corrected

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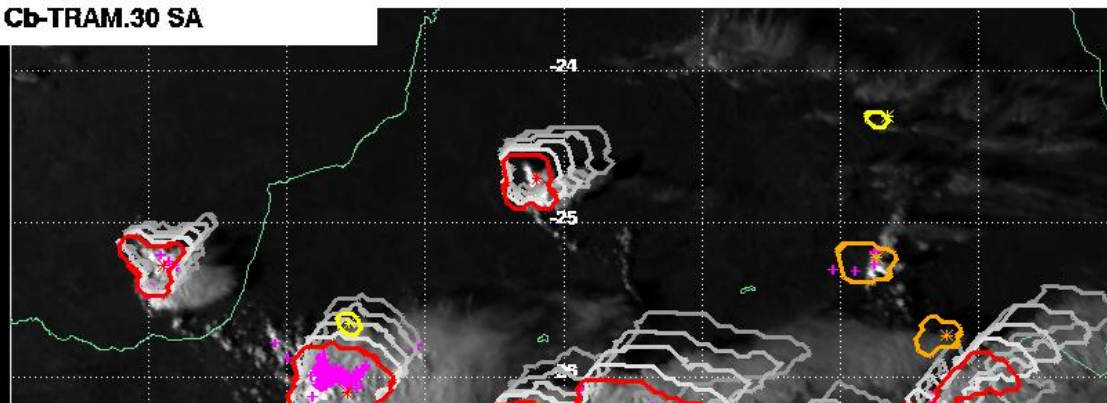
# CB-TRAM over South Africa



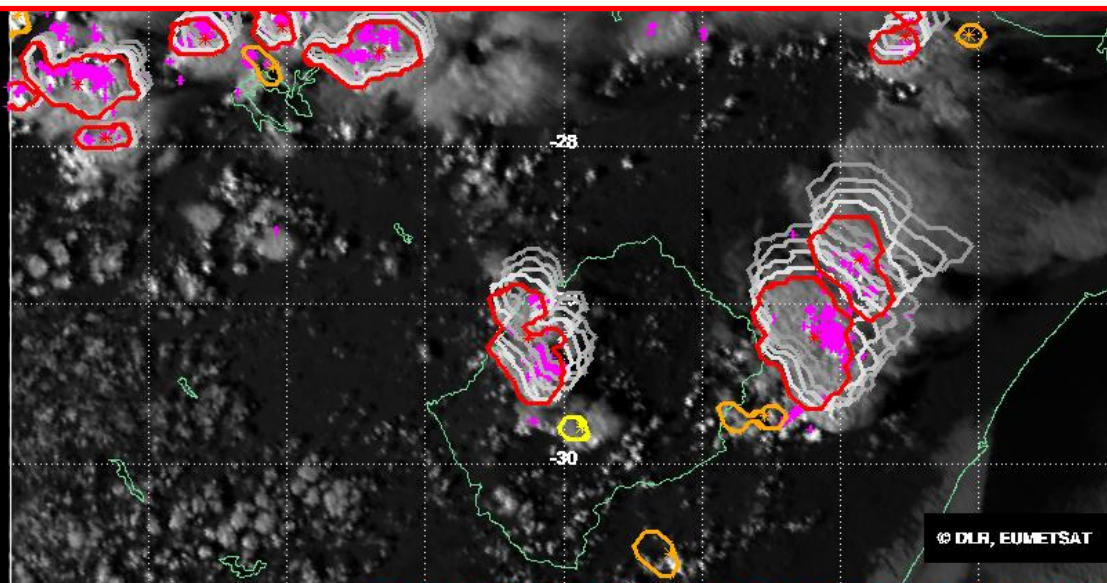
Cb-TRAM

23.10.2009 14:45 UTC Meteosat9 HRV

Cb-TRAM.30 SA



Cb-TRAM is able to nowcast the development and movement of the Cb cells up to one hour



parallax corrected

EXPERIMENTAL PRODUCT! NOT FOR OPERATIONAL USE!

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15, 30, 45, 60 Min.  
nowcast

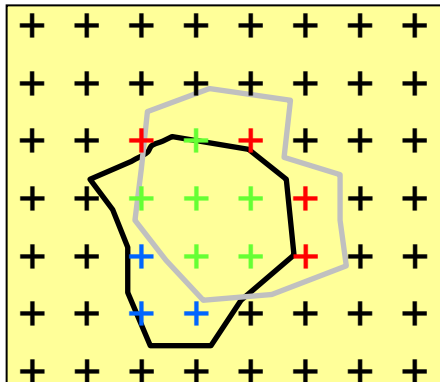
© DLR, EUMETSAT



# Evaluation of nowcast with detected Cb TRAM cells

## pixel-based analysis (requires exact match of objects)

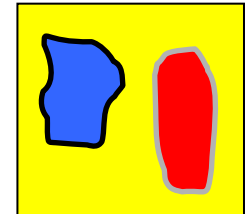
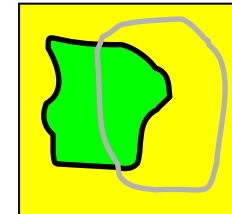
- hit = nowcast matches observation at a pixel
- miss = observation which is not nowcast at a pixel
- false alarm = nowcast which is not observed at a pixel



black: observed object at time t  
grey: nowcast object for time t  
blue: misses  
red: false alarms  
green :hits

## object-based analysis (does not require exact match of objects)

- hit = nowcast object overlaps observed object
- miss = observed object which is not nowcast
- false alarm = nowcast object which is not observed

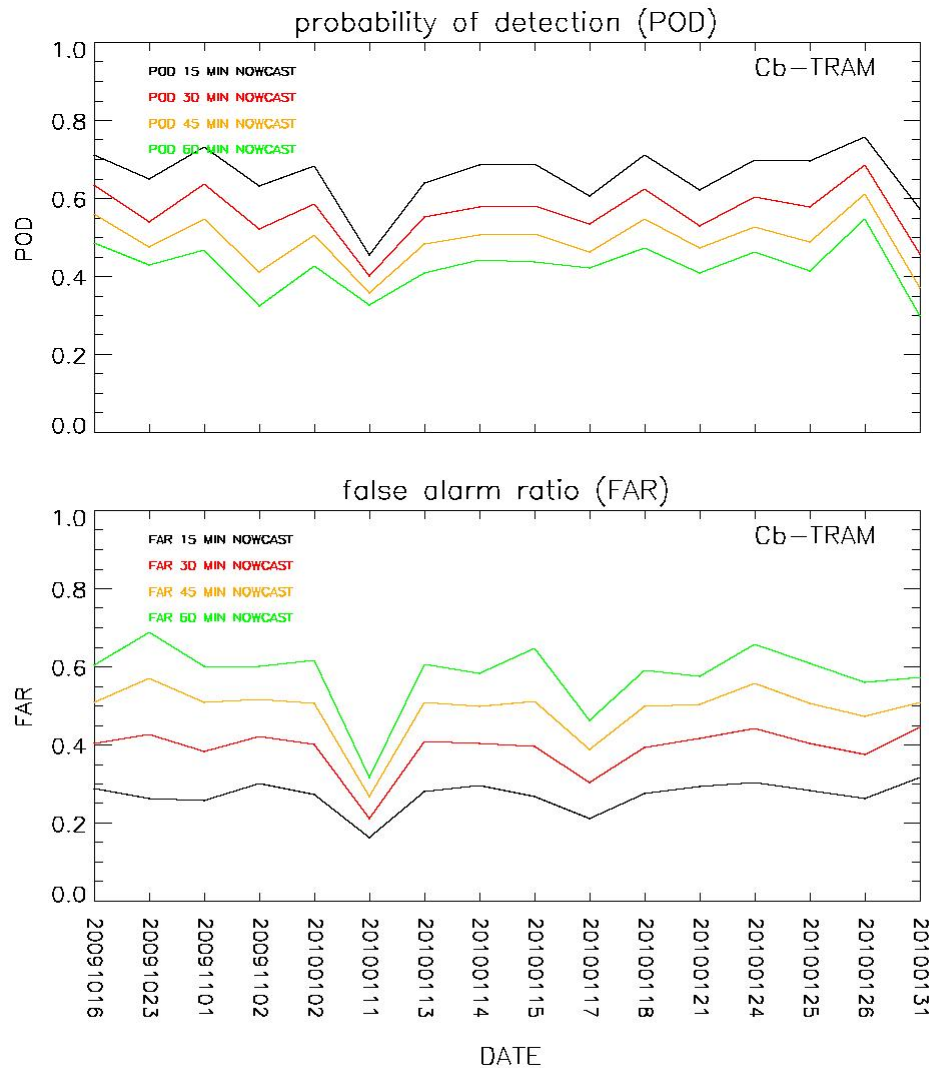


$$\text{POD} = \text{hits} / (\text{hits} + \text{misses})$$

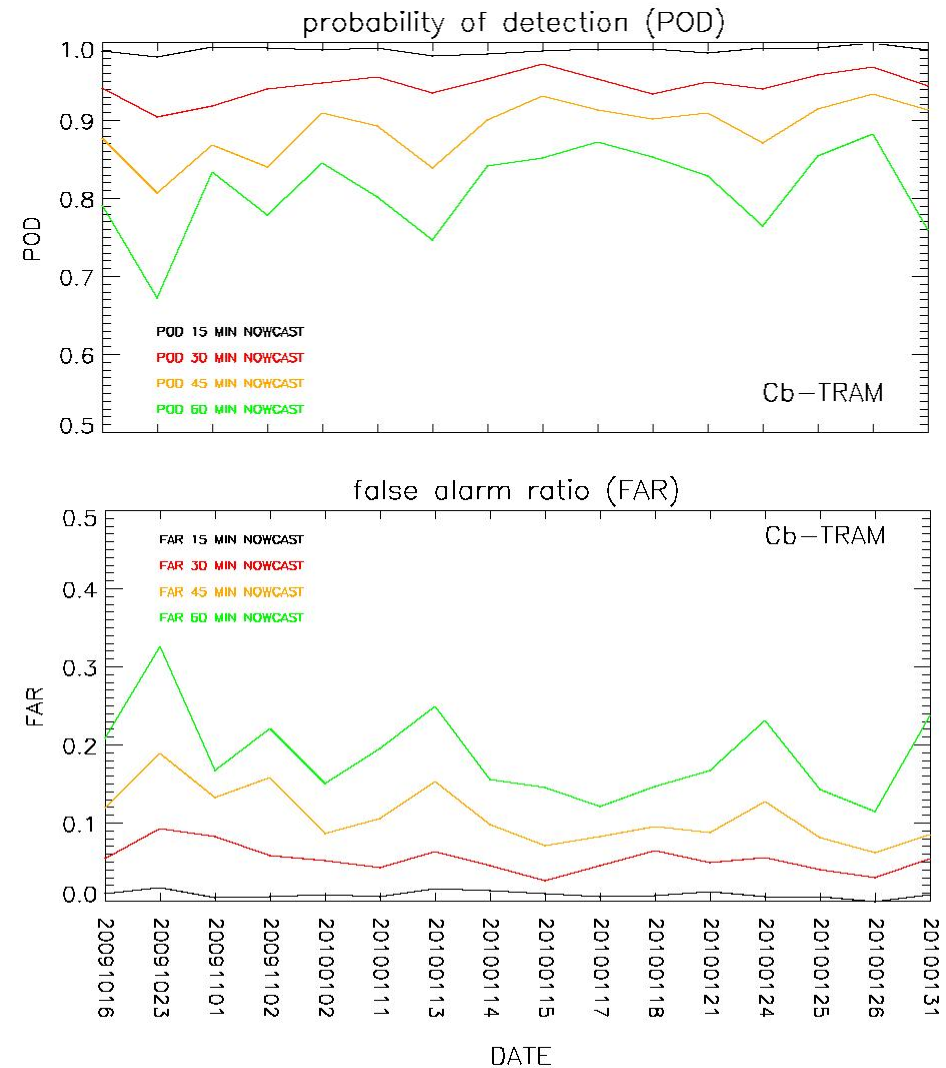
$$\text{FAR} = \text{false alarms} / (\text{hits} + \text{false alarms})$$

# Evaluation of nowcast with detected Cb TRAM cells

pixel-based analysis



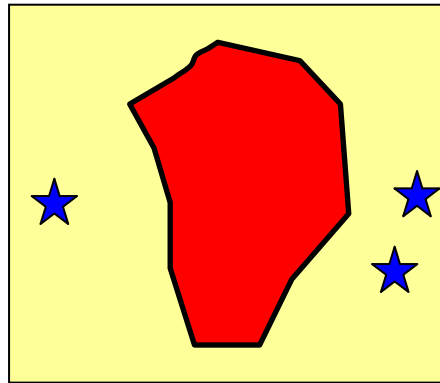
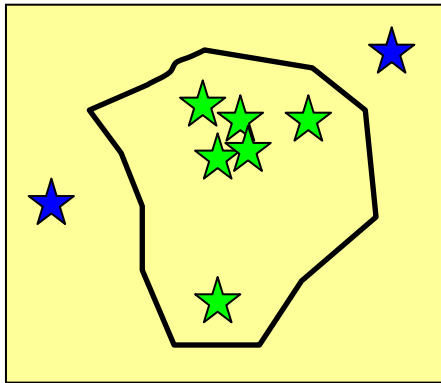
object-based analysis (note the scale!)





# Simple evaluation of detected/nowcast Cb TRAM cells with lightning data

- hit = lightning incident inside of Cb-TRAM cell
- miss = lightning incident outside of Cb-TRAM cell
- false alarm = Cb-TRAM cell without lightning

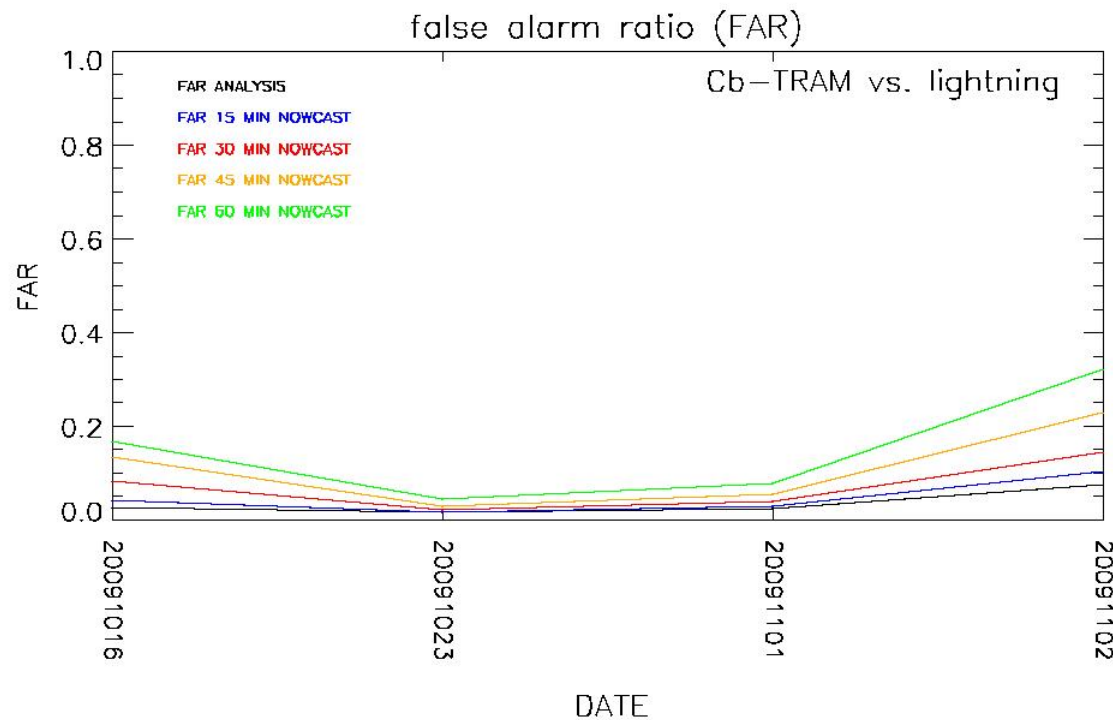
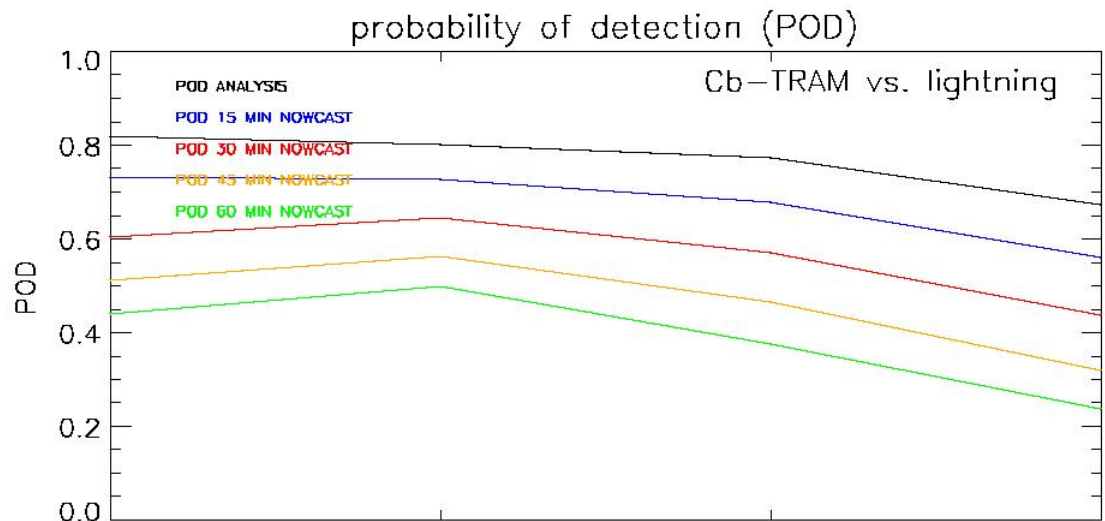


black contour: observed Cb object at time t  
green stars: lightning incidents (hits)  
blue stars: lightning incidents (misses)  
red object: object without lightning (false alarm)

$$\text{POD} = \text{hits} / (\text{hits} + \text{misses})$$

$$\text{FAR} = \text{false alarms} / (\text{hits} + \text{false alarms})$$

# Simple evaluation of detected/nowcast Cb TRAM cells with lightning data



note that cells indicating CI and do (correctly) not (yet) contain lightning are also included in this analysis and are counted as false alarms

also single lightning events that do not belong to lightning clusters and are typically not related to Cb-TRAM cells are included and counted as misses





# Summary and conclusions

## ➤ Cb-TRAM

- has successfully been applied over South Africa for the first time
  - detects the most active regions within a thunderstorm
  - is able to detect convection initiation before any lightning incident occurs
  - is able to nowcast the movement and development of thunderstorms up to one hour
- The evaluation of nowcast with detected Cb-TRAM cells shows that
- pixel-based POD = 75%, FAR = 25% (15 min nowcast)
  - object-based POD = 98%, FAR = 3% (15 min nowcast)
  - POD decreases with increasing lead time, while FAR increases
  - the nowcasting for lead times greater 30 minutes has to be improved
- The evaluation of Cb-TRAM detections and nowcasts with lightning data shows that
- Cb-TRAM agrees generally well with lightning data (POD = 80%, FAR = 5%)

**Cb-TRAM is a useful tool for the (early) detection, tracking and nowcasting of thunderstorms over South Africa**